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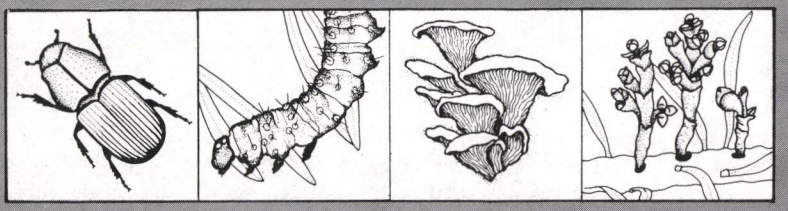

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INCIDENCE OF ROOT PATHOGENS ON DOUGLAS-FIR WITHIN THE REUBEN'S RESERVE, NEZ PERCE INDIAN RESERVATION, IDAHO

by

R. L. James, Plant Pathologist

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ABSTRACT

Root diseases were evaluated on the Reuben's Reserve, Nez Perce Indian Reservation, Idaho. Nineteen trees adjacent to two suspected root disease centers were pushed with a D-6 tractor to expose their root systems. Extent of root necrosis and decay was determined and related to level of crown thinning, chlorosis, and dieback. All excavated trees were infected with Phaeolus schweinitzii; some trees with severe root deterioration lacked crown decline symptoms typical of root disease. Evidence of insect activity was often found in the root crown or bole of trees with extensive root necrosis and decay. A black staining organism, Verticicladiella antibiotica, was isolated from roots of two trees. Implications of root diseases in management of Douglas-fir in the Reserve are discussed.

INTRODUCTION

Root diseases commonly occur on the Nezperce Indian Reservation in Idaho (James 1981). Although many different conifer species can be infected, Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) is one of the most susceptible hosts. The most common root pathogen previously encountered on the Reservation and nearby forest lands was Armillaria mellea (Vahl. ex Fr.) Kummer, cause of shoestring root rot (James 1981). Douglas-fir infected with this pathogen often display crown symptoms including thin, chlorotic foliage and extensive cone production. Other indications of root infection include basal resinosis, mycelial fans under the bark, black rhizomorphs around the base or along infected roots, and occasional production of golden-colored mushrooms around the base of infected trees (Morrison 1981).

Because of the importance of root diseases on management of conifers within the Nez Perce Indian Reservation, an evaluation was conducted to identify common pathogens associated with root infection and decay on the Reuben's Reserve. The evaluation was also designed to relate extent of root infection to level of crown decline so that foresters might more reliably predict infection from above-ground indicators.

United States Department of Agriculture | Forest Service | Northern Region | P.O. Box 7669 Missoula, Montana 59807

METHODS

This evaluation was conducted on the Reuben's Reserve within portions of Sections 20 and 21, T35N, R2W, on the Nez Perce Indian Reservation in central Idaho. The stand evaluated was approximately 85 years old and made up primarily of Douglas-fir; a few scattered ponderosa pine (Pinus ponderosa Laws.) were mixed in the stand and grand fir (Abies grandis (Dougl.) Lindl.) occupied cool, wet sites along several stream bottoms.

At the time of the evaluation, the stand was being harvested using a shelterwood system which favored ponderosa pine. Scattered throughout the stand were several centers of current tree mortality. Mortality had been occurring for a long time because old snags and down trees were common within these centers.

Previous examination of the Reuben's Reserve (James 1981) had indicated that Douglas-fir mortality was associated with attacks by Douglas-fir bark beetle (Dendroctonus pseudotsugae Hopkins). Armillaria root disease was common on grand fir near stream bottoms.

Excavation of entire root systems was necessary to obtain information on pathogens present and extent of root infection and decay. The two sites selected for root excavation were adjacent to suspected root disease centers which had recent tree mortality. Nineteen dominant or codominant trees were selected for excavation adjacent to or within 35 m of suspected disease centers. Selected trees included those with healthy looking crowns as well as a few with thin or necrotic foliage. Selected trees were pushed by a D-6 tractor to expose their root systems. Root systems were systematically examined for root necrosis, staining, abnormal morphology, and decay. Samples of stained or necrotic roots were collected from each excavated tree for laboratory isolations of associated fungi. Percentage of each root system that was necrotic or decayed was visually estimated.

RESULTS AND DISCUSSION

All excavated trees near suspected disease centers had roots infected with Phaeolus schweinitzii (Fr.) Pat. (Table 1). Surprisingly, Armillaria was not found on any excavated tree. Infection by P. schweinitzii occurred regardless of presence or absence of crown symptoms. Thirteen of the infected trees had healthy appearing crowns. Trees with extensive root decay and necrosis generally had thin or necrotic crowns, although there were two notable exceptions. Two trees on site I (#2 and 11) had extensive root infection, but healthy looking crowns.

Large roots severely infected by P. schweinitzii had typical brown cubical decay with thin fungus mats between cubes. Several infected roots also had galls which apparently result from host callus formation at points of infection (Dubreuil 1981). Necrosis of small feeder roots was common on most examined trees. Large roots of trees with slight infection usually appeared structurally sound. The bark of many necrotic roots was dark brown and easily sloughed off.

Table 1.--Relationships between Douglas-fir crown symptoms and root system necrosis or decay caused by pathogens at the Reuben's Reserve, Nez Perce Indian Reservation, Idaho.

Tree number	D.B.H. (cm)	Crown symptoms 1/	% root system necrotic or decayed	Associated fungi 2/	Other organisms
Site I					
1	27.2	Healthy	5	P.S.	--
2	24.5	Healthy	85	P.S.	Root crown insects
3	37.0	Very thin	90	P.S.	Root crown insects
4	28.5	Thin	85	P.S.	Root crown insects
5	29.0	Necrotic	95	P.S.	Cryptoporus volvatus Douglas-fir beetle
6	20.5	Healthy	15	P.S. & V.A.	Douglas-fir beetle and root crown insects
7	25.0	Healthy	10	P.S.	--
8	20.0	Healthy	5	P.S.	--
9	23.5	Healthy	5	P.S.	--
10	20.0	Thin	75	P.S.	--
11	23.0	Healthy	50	P.S.	--
Site II					
1	22.0	Healthy	20	P.S.	--
2	25.0	Healthy	5	P.S.	--
3	26.0	Healthy	5	P.S.	--
4	26.0	Thin	90	P.S. & V.A.	Root crown insects
5	23.0	Healthy	5	P.S.	--
6	26.0	Thin	85	P.S.	Root crown insects
7	9.3	Healthy	5	P.S.	--
8	9.6	Healthy	5	P.S.	--

1/ Crowns
Healthy - foliage without apparent chlorosis, thinning, or dieback.
Thin - 50 percent or less of the crown with chlorotic, thinned foliage or with branch dieback.
Very thin - Greater than 50 percent of the crown with chlorotic or thin foliage or branch dieback.
Necrotic - Crown with dead foliage (red or brown in color).

2/ P.S. = Phaeolus schweinitzii.
V.A. = Verticicladiella antibiotica - pathogenicity of isolates not confirmed.

Insect activity was found at the root crown of several trees with severe root deterioration (Table 1). Blue stains found within root systems of insect-attacked trees were generally light in color and either found throughout most sapwood or formed radial patterns indicating colonization of ray cells. Black stains were only found on the roots of two trees (#6 - Site I; #4 - Site II). Black stain was located on small roots 1.5-2 cm in diameter located at the bottom of the root ball some distance from the root crown.

The organism isolated from black stained roots was Verticicladiella antibiotica Ken. (see Appendix for more complete description).

Two sampled trees had been attacked by the Douglas-fir bark beetle (Dendroctonus pseudotsugae) (Table 1). The first attacked tree had red-brown, necrotic foliage and was also infected with the common saprot fungus, Cryptoporus volvatus (Pk.) Hubbard. The other attacked tree was infected with V. antibiotica.

CONCLUSIONS

Phaeolus schweinitzii is probably common on Douglas-fir throughout forest stands within the Reuben's Reserve. Infected trees may lack crown symptoms characteristic of root disease. Detection of these infected trees is difficult without examining a large portion of their root systems. Root crown examination will usually not reveal presence of the fungus.

Where pockets of Douglas-fir mortality occur, trees have been attacked by both root diseases and insects. Insects likely attack trees sufficiently weakened by root disease. Fungi causing blue and black staining of roots are associated with insect attacks.

Decline symptoms and mortality of Douglas-fir can be expected to increase as the stand is carried beyond an 80- to 90-year rotation, primarily because of increased susceptibility to insects caused by root disease. Therefore, converting much of the stand to a higher percentage of ponderosa pine should improve site productivity during the next and subsequent rotations. With lower levels of Douglas-fir, P. schweinitzii should become less of a future concern in management of the stand.

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APPENDIX

Black stain (*Verticicladiella antibiotica*) on Douglas-fir roots on the Reuben's Reserve.

The stain pattern was concentric with the annual rings rather than wedge-shaped. Microscopic examination of black stained roots revealed that pigmented hyphae were restricted to the tracheids and did not penetrate ray parenchyma cells (fig. 1). Movement of hyphae among tracheids occurred through bordered pit pairs. This colonization pattern is also characteristic of black stain root disease (Smith and Graham 1975). However, the fungus differed from *V. wageneri* Ken., (=*Ceratocystis wageneri* Goheen and Cobb) cause of black stain root disease (Smith and Graham 1975), in several ways. The major difference was that *V. antibiotica* had distinct rhizoids at the base of conidiophores (fig. 2), whereas *V. wageneri* generally lacks these structures (Kendrick 1962). The sporogenous apparatus was also different from *V. wageneri* (see below).

The following hyphal characteristics were found in black stained roots:

a. Hyphae were restricted to the longitudinal tracheids within sapwood.

b. No hyphae penetrated or colonized ray parenchyma cells (fig. 1).

c. Hyphae traversed tracheids through bordered pits.

d. Hyphae were of an orange-brown pigment and were restricted to stained portions of the wood.

Description of the organism associated with black stained roots:

1. Conidiophore morphology (description from natural wood substrate).

   a. Conidiophores were long, mononematous, with brown pigmented stipes.

   b. Stipes were septate (8-9 septa each), 650-750 μ in length, had vacuoles upon aging, and groups of light brown rhizoids at their bases (fig. 2). Rhizoids were septate and became subhyaline toward their base.

   c. Stipes were 8-12 μ in width at their base, gradually tapering to 5-7 μ just below the sporogenous apparatus.

   d. Thickness of the stipe wall decreased toward its apex.

2. Sporogenous apparatus.

   a. Length of the apparatus (exclusive of conidia) was 35-50 μ.

b. There were 3-4 primary metulae measuring 10-15 μ in length by 2-5 μ in width.

c. There were usually 2-3 series of metulae which decrease in pigmentation with each series.

d. Primary metulae were lighter in pigmentation than the stipe.

3. Sympodulae (cells bearing conidia).

a. Sympodulae were hyaline, unbranched, slightly tapered at their end, and measured 7-10 μ in length by 1-2 μ in width.

4. Conidia

a. Conidia were round to slightly clavate and measured 3-6 μ by 1-2 μ in size.

b. Conidia were individually hyaline and accumulated in a shiny head that appeared cream colored at the tip of conidiophores.

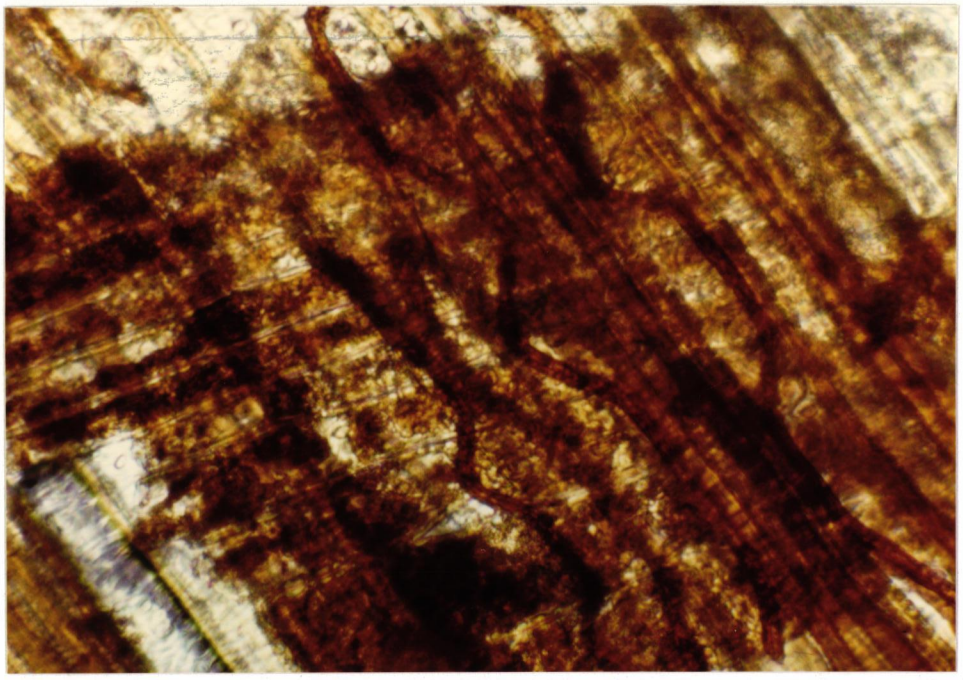

Figure 1.--Hyphae of Verticicladiella antibiotica within tracheids of Douglas-fir roots. Note that hyphae do not penetrate into the ray parenchyma cells.

Figure 2.--Conidiophores of Verticicladiella antibiotica with distinctive rhizoids at their base.